

## DESCRIPTION

SCAFFOLD APPARATUS FOR OPERATIONS ON INNER WALL SURFACE OF TOWER  
STRUCTURE AND OPERATIONAL METHOD FOR INNER WALL SURFACE USING

5 THE SAME

## TECHNICAL FIELD

The present invention relates to a scaffold apparatus for  
conducting operations on an inner wall surface of a tower  
10 structure, used for conducting a variety of operations on the  
inner wall surface of a tall tower structure with a blast furnace  
type structure, such as the digester provided in a paper  
production plant, as well as an operational method for an inner  
wall surface using such a scaffold apparatus.

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## BACKGROUND ART

Generally, in a tower structure, maintenance is essential  
in ensuring retention of the tower functions over an extended  
period, and the inner wall surface of the tower in particular  
20 is exposed to severe temperature and pressure conditions, or  
a corrosive environment of chemicals or the like, and  
consequently frequent maintenance operations such as  
inspections, cleaning, modifications and welding must be  
undertaken.

25 However, a tower structure is tall, and the operational  
target zone extends over a wide height range, from regions near  
the bottom of the tower to regions near the top, and because

the operations on the inner wall surface of such a tower structure require both operators and a variety of operational materials, an operations scaffold must be put up inside the tower structure. Conventionally, the most typical method of assembling this type of operations scaffold has usually involved assembling a scaffold framework inside the tower, and then providing an operations footing on top.

However, according to this operations scaffold assembling method using a scaffold framework, each time the operating height is altered, a level adjustment operation requiring the addition of further scaffold framework is required, and consequently the operating efficiency is extremely poor, and because these level adjustment operations are conducted at considerable height, problems also arise regarding the safety of the actual level adjustment operation itself.

Accordingly, an object of the present invention is to provide a scaffold apparatus for conducting operations on an inner wall surface of a tower structure, which enables operations on the inner wall surface of the tower structure to be conducted safely and with good operability, as well as an operational method that utilizes such a scaffold apparatus.

#### DISCLOSURE OF THE INVENTION

A scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to a first aspect of the present invention comprises either a single post or a plurality of posts put up inside a tower structure from a bottom

section thereof toward a top section, and a height adjustable operations platform that is attached to the posts in a manner of freely movable in up or down direction.

By using this type of construction, a scaffold apparatus  
5 for conducting operations on an inner wall surface of a tower structure according to the first aspect of the present invention comprises either a single post or a plurality of posts put up inside a tower structure from a bottom section thereof toward a top section, and a height adjustable operations platform that  
10 is attached to the posts in a manner of freely movable in up or down direction, and consequently, putting up the posts inside the tower structure and then attaching the height adjustable operations platform means that when any of a variety of operations are conducted on the inner wall surface of the tower  
15 structure, adjustments of the installation height of the height adjustable operations platform within the tower structure (that is, the height position at which operations are conducted using the height adjustable operations platform) are performed easily and quickly by moving the height adjustable operations platform  
20 up or down along the posts. As a result, compared with a conventional case in which, for example, a level adjustment operation such as adding to the scaffold framework is required inside the tower structure every time the operating height is altered, the operability of inner wall surface operations  
25 improves markedly, and because level adjustment operations need not be conducted at great heights, the safety of the operations also improves, meaning both operating cost reductions and

improved safety are achieved.

Furthermore, a second aspect of the present invention is the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to the first aspect  
5 of the present invention, wherein the posts are put up by sequentially stacking and connecting a plurality of posts pieces, which are of dimensions that enable transport through a materials transport port provided in the tower structure, from the bottom section of the tower structure toward the top section.

10 By using this type of construction, a scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this second aspect of the present invention offers the following characteristic effects in addition to the effects provided by the first aspect of the  
15 invention. Namely, in the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this aspect of the present invention, the posts are put up by sequentially stacking and connecting a plurality of posts pieces, which are of dimensions that enable transport  
20 through a materials transport port provided in the tower structure, from the bottom section of the tower structure toward the top section, and consequently, even though the operation must be conducted under the restricted operational space conditions unique to tower structures, a post of any height is  
25 put up easily by carrying the required number of post pieces into the tower structure and then sequentially combining the pieces. As a result, the scaffold apparatus is applied to inner

wall surface operations within a variety of different tower structures of different heights, enabling an improvement in the general-purpose applicability of the scaffold apparatus.

In addition, a third aspect of the present invention is the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to either of the first or second aspects of the present invention, wherein the bottom end of each post is supported by a lower support base, which is secured immediately above a tower bottom section via securing pieces provided on the side wall of the tower structure immediately above the tower bottom section.

By adopting these types of features, a scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this third aspect of the present invention offers the following characteristic effects in addition to the effects provided by the first and second aspects of the invention. Namely, in the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this aspect of the present invention, the bottom end of each post is supported by a lower support base secured immediately above a tower bottom section via a securing piece provided on the side wall of the tower structure immediately above the tower bottom section, and consequently the entire weight, including the dead load of the posts and the attached height adjustable operations platform, and the weight of any operators and/or operating materials loaded onto this height adjustable operations platform, is supported directly

by the side walls at a point immediately above the tower bottom section of the tower structure, via the aforementioned lower support base, and the application of load onto the tower bottom section is avoided.

5           As a result, compared with the case in which the entire weight of the aforementioned posts and the like is supported by the tower bottom section of the tower structure, that is, the region that is typically constructed from an end plate with a curved surface, the weight of the posts and the like is supported more reliably and in a more stable manner, and both the reliability of the installation of the posts and the like, and the reliability of the various operations conducted using the posts and the attached height adjustable operations platform, are improved.

15           In addition, because the tower bottom section of the tower structure has the end plate structure described above, that section is more complex and more expensive to produce than the side wall section, and consequently by not needing to use this tower bottom section as the support site for the posts and the like, damage to the tower bottom section is effectively avoided, resulting in an improvement of the durability of the tower structure, or a reduction of the production costs.

25           Furthermore, a fourth aspect of the present invention is the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to the first aspect of the present invention, wherein the height adjustable operations platform is a knockdown structure that is capable

of being transported through a materials transport port provided in the tower structure.

By using this type of construction, a scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this fourth aspect of the present invention offers the following characteristic effects in addition to the effects provided by the first aspect of the invention. Namely, in the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this aspect of the present invention, the height adjustable operations platform is a knockdown structure that is capable of being transported through a materials transport port provided in the tower structure, and consequently even though the operation must be conducted under the restricted operational space conditions unique to tower structures, a height adjustable operations platform having any of a variety of different shapes (namely, a shape that corresponds with the internal dimensions of the target tower structure) is assembled easily by carrying the disassembled members into the tower structure and then sequentially combining the members, and as a result, the scaffold apparatus become applied to inner wall surface operations within a variety of different tower structures of different internal dimensions, enabling an improvement in the general purpose applicability of the scaffold apparatus.

Furthermore, a fifth aspect of the present invention is the scaffold apparatus for conducting operations on an inner

wall surface of a tower structure according to the fourth aspect of the present invention, wherein the height adjustable operations platform is equipped with elevation drive means that enables the platform to be raised and lowered under its own power, and the external periphery of the height adjustable operations platform is equipped with guide wheel units that are provided with a wheel, which displaces freely toward, and away from, the inner wall surface of the tower structure and is held in continuous contact with the inner wall surface by a predetermined pressure.

By using this type of construction, a scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this fifth aspect of the present invention offers the following characteristic effects in addition to the effects provided by the fourth aspect of the invention. Namely, in the scaffold apparatus for conducting operations on an inner wall surface of a tower structure according to this aspect of the present invention, the height adjustable operations platform is equipped with elevation drive means that enables the platform to be raised and lowered under its own power, and the external periphery of the height adjustable operations platform is equipped with guide wheel units that are provided with a wheel, which displaces freely toward, and away from, the inner wall surface of the tower structure and is held in continuous contact with the inner wall surface by a predetermined pressure.

Accordingly, in a scaffold apparatus for conducting



operations on an inner wall surface according to this aspect of the present invention, because the height adjustable operations platform is capable of being raised and lowered under its own power, during various operations using the height adjustable operations platform, adjustments to the height of the height adjustable operations platform is performed easily and quickly, for example in accordance with the requirements of an operator, and consequently both the operability and mobility are good, meaning the operating efficiency of operations that are conducted using the height adjustable operations platform is improved markedly.

In addition, in this scaffold apparatus for conducting operations on an inner wall surface of a tower structure, because the height adjustable operations platform is equipped with the aforementioned guide wheel units, the following types of effects are achieved:

(1) the wheels of the guide wheel units are held in continuous contact with the inner wall surface by a predetermined pressure, and as a result of the bracing action provided by these wheels, sideways swinging during raising or lowering of the height adjustable operations platform is largely inhibited, enabling a more stable, smoother movement, and improving the safety during movement;

(2) in those cases in which an operator on the height adjustable operations platform performs an operation using any of a variety of operating materials, with the height adjustable operations platform secured at a predetermined height position, the bracing

action of the wheels of the guide wheel units prevents sideways rolling of the height adjustable operations platform, and ensures good safety on the height adjustable operations platform during operations; and

- 5 (3) because the wheels of the guide wheel units displace freely toward, and away from, the inner wall surface of the tower structure, even if, for example, there are irregularities along the height direction (that is, in the direction of movement for the height adjustable operations platform) of the tower
- 10 structure (for example, even if there are sections in which the internal diameter dimension of the tower structure changes), by utilizing the aforementioned displacement function, the wheels easily ride over such irregularities, and irregularities and the like in the inner wall surface cause absolutely no
- 15 impediment to the movement of the height adjustable operations platform, and as a result, stable vertical movement of the height adjustable operations platform is achieved, meaning the general purpose applicability of the scaffold apparatus for conducting operations on the inner wall surface of tower structures of a
- 20 variety of constructions is improved even further.

In addition, an operational method for an inner wall surface according to a sixth aspect of the present invention comprises the steps of loading people and/or an operating material onto a height adjustable operations platform, which

25 is attached to a single post or a plurality of posts put up inside a tower structure from a bottom section thereof toward a top section in a manner that enables free up or down movement along

the posts, and adjusting the operating height by moving the height adjustable operations platform up and down along the posts, while performing the required operations on the inner wall surface of the tower structure.

5 By using this type of operational method, in an operational method for an inner wall surfaces of a tower structure according to the sixth aspect of the present invention, people and/or operating materials are loaded onto a height adjustable operations platform, which is attached to a single post or a  
10 plurality of posts put up inside a tower structure from a bottom section thereof toward a top section in a manner that enables free up or down movement along the posts, and the operating height is adjusted by moving the height adjustable operations platform up and down along the posts, while the required  
15 operations are performed on the inner wall surfaces of the tower structure, and consequently, compared with a conventional case in which, for example, a level adjustment operation such as adding to the scaffold framework is required inside the tower structure every time the operating height is altered, the  
20 operating efficiency of inner wall surface operations improves markedly, and because level adjustment operations need not be conducted at great heights, the safety of the operations also improves, meaning operations realizes both cost reductions and improvement of safety.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a cross-sectional view of a tower structure

showing the operational state when a scaffold apparatus for conducting operations according to the present invention is used to perform any of a variety of operations on the inner wall surface of a digester.

5        FIG.2 is an enlarged view of the height adjustable operations platform section shown in FIG.1.

FIG.3 is a view along the arrow headed line III-III of FIG.1.

10        FIG.4 is an enlarged perspective view of the section IV shown in FIG.3.

FIG.5 is an enlarged cross-sectional view along V-V of FIG.3.

FIG.6 is an enlarged view along the arrow headed line VI-VI of FIG.1.

15        FIG.7 is an enlarged view along the arrow headed line VII-VII of FIG.1.

FIG.8 is an enlarged view along the arrow headed line VIII-VIII of FIG.7.

20        FIG.9 is an enlarged view of the section IX shown in FIG.7.

#### BEST MODE FOR CARRYING OUT THE INVENTION

As follows is a description of a scaffold apparatus for conducting operations and an operational method according to the present invention, using the case of a CO<sub>2</sub> blast cleaning operation of the inner wall surface of a digester (tower structure) with a blast furnace type structure employed in a paper production plant as an example.

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FIG. 1 shows a digester 1, with a scaffold apparatus for operations, which is used for conducting a cleaning operation of the inner wall surface, erected therein.

A: Configuration of the Digester 1

5       The digester 1 is, for example, a large scale, tall, closed vessel with an internal diameter of 4 to 5 meters and a height of 40 to 50 meters, and is classified as a type-1 pressure vessel in the safety standards. Accordingly, the state of the inner wall surface must be inspected for safety purposes, and where  
10       necessary, required inner wall surface repair operations, such as the repair, by welding, of reduced thickness sections caused by cracking or abrasion of the inner wall surface, must be carried out. When this type of welding repair of the inner wall surface is required, the inner wall surface must first be  
15       subjected to a cleaning operation as a preparatory operation. In this embodiment, a cleaning operation using a CO<sub>2</sub> blast device, which acts as a preparatory operation for a welding repair operation, is described as an example of an operation that uses the scaffold apparatus for operations.

20       As follows is a simple description of the construction of the digester 1, which represents the operation target.

      The digester 1 is formed as a sealed vessel, comprising a main body section 2 with a large diameter cylindrical structure, and a digester bottom structure 3 with an end plate construction  
25       joined at the bottom end and a digester top structure 4 joined at the top end, and is fixed in a vertical position with a bottom section 1a of the digester bottom structure 3 supported on a

base 5.

Furthermore, the main body section 2 has a so-called "bamboo construction" wherein the diameter dimension reduces in a stepwise manner from the bottom section 1a of the digester 1 through to a top section 1b, and comprises a first main body section 21 that has the largest diameter and is joined to the top edge of the digester bottom structure 3, a second main body section 22, which is of a smaller diameter than the first main body section 21 and is joined so that the bottom end thereof is inserted inside the top end of the first main body section 21, and a third main body section 23, which is of a smaller diameter than the second main body section 22, is joined so that the bottom end thereof is inserted inside the top end of the second main body section 22, and which has the aforementioned digester top structure 4 joined to the top end thereof. Accordingly, an inner wall surface 1d of the main body section 2 has a stepped structure in which the internal diameter dimension varies at the joint regions between the first main body section 21 through the third main body section 23. Consequently, a height adjustable operations platform 8 described below, which is used during cleaning operations of the inner wall surface 1d, has a structure that enables vertical movement from the first main body section 21 through to the third main body section 23 without being affected in any way by the steps at the joint sections between the main body sections.

Furthermore in this embodiment, when a cleaning operation using CO<sub>2</sub> blasting is conducted on the inner wall surface of

the digester 1, in order to ensure good ventilation through the inside of the digester 1, manholes that are provided in the digester 1 for that purpose are used. In other words, the CO<sub>2</sub> blasting is a technique in which fine particles of dry ice are projected at the target surface as a blast material, and during the blasting operation, because CO<sub>2</sub> gas accumulates at the bottom inside the digester 1, in order to generate a downward ventilation flow inside the digester 1, an exhaust system 32 is attached to a bottom manhole 31 provided in a central position within the digester bottom structure 3, exhaust systems 33, 34 are disposed at a pair of upper and lower manholes provided toward the top section 1b, and an air supply device 37 is provided at a large diameter manhole 35 provided substantially halfway up the digester. This ventilation system ensures a good working environment inside the digester 1, and guarantees a highly safe operation.

In addition, a manhole 36 provided near the joint section between the digester bottom structure 3 and the first main body section 21 of the digester 1 is used for carrying materials in and out of the digester 1, and for people to enter or exit from the digester 1.

#### B: Configuration of the Scaffold Apparatus for Operations

As shown in FIG. 1, the aforementioned scaffold apparatus for operations comprises a left and right pair of posts 16, which are put up from the bottom section 1a of the digester 1 toward the top section 1b, and the bottom ends of which are supported by a lower fixed operations floor 6 and the top ends of which

are supported by an upper fixed operations floor 7, and a height adjustable operations platform 8 which moves up and down along each of these posts 16.

The aforementioned lower fixed operations floor 6, the upper fixed operations floor 7, the height adjustable operations platform 8, and the posts 16 that make up the scaffold apparatus for operations are all divided structures, and are each carried into the digester 1 in a disassembled state through the manhole 36, and then assembled inside the digester 1. As follows is a description of each of the structural elements, in the order in which they are assembled.

#### B-1: Lower Fixed Operations Floor 6

The lower fixed operations floor 6 corresponds with the "lower support base 6" disclosed in the claims, and is the first structure assembled during erection of the scaffold apparatus for operations.

In other words, as shown in FIG. 1, the lower fixed operations floor 6 is secured near the boundary between the straight region and the curved region of the aforementioned digester bottom structure 3 of the digester 1 (see FIG. 4), and in addition to its original function as an operations platform, also performs the important function of acting as a support base for the posts 16 described below.

As shown in FIG. 3, the lower fixed operations floor 6 is constructed by assembling four support girders 43 in a cross girder arrangement, and then installing and securing a flooring material 44 in a circular shape, the periphery of which extends



out to a position close to, and facing the inner wall surface 1d of the digester 1, onto the top of these support girders 43. Furthermore, a left and right pair of support bases 41, 41 for mounting and supporting the bottom ends of the posts 16 described below are provided in positions toward the center of the lower fixed operations floor 6, and positioning stoppers 42 for restricting the sideways movement of the bottom ends of the posts 16 are provided on these support bases 41 (see FIG. 5).

As described above, the lower fixed operations floor 6 is carried from outside the digester 1, through the manhole 36 and into the digester in a disassembled state, where it is then assembled, and consequently all of the structural members must be formed from parts that are of a size capable of passing through the manhole 36, and must be bolt secured structures that are capable of being assembled and disassembled.

Accordingly, in an assembly procedure for the lower fixed operations floor, first, the four support girders 43 are carried into the digester 1, and assembled in a cross girder arrangement inside the digester 1. In other words, as shown in FIG. 4, eight securing pieces 45 are welded to the inner wall surface 1d at a position directly above the aforementioned digester bottom structure 3 of the digester 1 in advance, with a predetermined spacing in the circumferential direction. Each securing piece 45 is then attached to a connecting member 46 via a bolt 18, and the end section of a support girder 43 is then secured to the connecting member 46 via a bolt 19. The reason that the securing pieces 45 and the support girders 43 are joined together

via the aforementioned connecting members 46 is to enable ready compatibility with changes in the structure of the support girders 43. Furthermore, when the operations have been completed and the lower fixed operations floor 6 has been  
5 disassembled and removed, these securing pieces 45 remain attached to the digester 1, and are used in the next operation.

#### B-2: Posts 16

As shown in FIG. 1, FIG. 2, and FIG. 9, the posts 16 are put up inside the digester 1 so as to extend from the  
10 aforementioned lower fixed operations floor 6 through to the upper fixed operations floor 7 described below, and in this embodiment two posts 16 are arranged in parallel with a predetermined spacing therebetween, and are connected by joint members 17, forming an approximately ladder type structure.  
15 The number of posts 16 to be installed is appropriately selectable upon the needs, and either a single post, or a set of three or more posts, may be used.

As described above, the posts 16 are carried from outside the digester 1, through the manhole 36, and are then assembled  
20 inside, and in this embodiment, a plurality of truss structured post pieces 16a with a rectangular cross-section (see FIG. 9) and a length that represent a size capable of passing through the manhole 36 are prepared, and these are then joined together sequentially in an axial direction to form a column type  
25 structure.

In other words, the post pieces 16a are carried onto the lower fixed operations floor 6 via the manhole 36. Then, as

shown in FIG. 3 and FIG. 5, first, two post pieces 16a are put up on top of the aforementioned support bases 41 of the lower fixed operations floor 6, positioned in place by the positioning stoppers 42, and then secured in place with bolts (not shown in the drawings). Subsequently, a predetermined number of additional post pieces 16a are stacked on top of, and connected to, the bottommost post pieces 16a, sequentially increasing the height of the posts, and the uppermost post pieces 16a that are joined last are secured to the upper fixed operations floor 7 described below. Furthermore, a rack 15 (see FIG. 9) that extends in the axial direction is provided on the post pieces 16a, and when a plurality of post pieces 16a are joined together to form a post 16, these racks 15 also extend continuously from the bottom end of the post 16 to the top end.

The operation for stacking and joining the post pieces 16a, the assembly of the upper fixed operations floor 7, and the operation for joining the floor to the top end of the posts 16, are carried out using the height adjustable operations platform 8 described below. In other words, in the operation of putting up the posts 16, once the bottommost post pieces 16a have been attached, the aforementioned height adjustable operations platform 8 is assembled on the lower fixed operations floor 6 and attached to these post pieces 16a, and is then raised and lowered along these post pieces 16a. This height adjustable operations platform 8 is then moved sequentially upward, while the post pieces 16a are sequentially stacked and joined together. Furthermore, in this case, the disassembled parts for the

aforementioned upper fixed operations floor 7 are loaded onto the height adjustable operations platform 8, and following completion of the joining operation of the uppermost post pieces 16a, the upper fixed operations floor 7 is assembled on top of the height adjustable operations platform 8 and then secured to the top end of the posts 16 (namely, the top end of the uppermost post pieces 16a). This completes the assembling of the posts 16, the bottom ends of which are supported by the lower fixed operations floor 6, and the top ends of which are supported by the upper fixed operations floor 7.

#### B-3: Upper Fixed Operations Floor 7

The upper fixed operations floor 7 corresponds with the "upper support base" disclosed in the claims, and as shown in FIG. 1, is disposed at a position immediately below the digester top structure 4 of the digester 1, and in addition to functioning as an operations floor as per its original function, also performs the important function of acting as a top end support base for the posts 16 as described above.

As shown in FIG. 6, the upper fixed operations floor 7 is a circular, flat shape, and is positioned inside the side walls 1c of the digester 1 with a predetermined space retained between the floor and the side walls 1c. Furthermore, the upper fixed operations floor 7 supports the top ends of the aforementioned pair of posts 16, 16 via a left and right pair of post securing members 50, 50 that are provided toward the center of the floor, while movement in the horizontal direction is regulated by bracing the tips of jacks 51, 51, ..., which are

provided at four locations around the outer periphery of the floor, against the inner wall surface 1d of the side walls 1c.

In the same manner as the lower fixed operations floor 6 described above, this upper fixed operations floor 7 is also a knockdown structure that is bolted together, and is carried into the digester 1 through the aforementioned manhole 36, and then assembled on top of the height adjustable operations platform 8.

#### B-4: Height Adjustable Operations Platform 8

The height adjustable operations platform 8 is used as an operations floor for the cleaning operation conducted on the inner wall surface 1d of the digester 1 as in this embodiment, but is also used as the operations floor for a wide variety of other operations such as inspection operations or repair operations conducted on the inner wall surface 1d, and for the transport and transfer of operating materials or operators during any of these operations.

As shown in FIG. 7, the height adjustable operations platform 8 is formed as a circular shaped flat structure by attaching a flooring material 49 to the top of girder members 47, 48 that are assembled in a cross girder arrangement, with a predetermined spacing maintained between the periphery of the platform and the inner wall surface 1d of the digester 1. A left and right pair of post guides 62, 62 are provided in the central region of this height adjustable operations platform 8, and the aforementioned posts 16, 16 pass through each of these post guides 62, 62. Pinion gears 40 that are rotated and driven

by travel drive motors 30 (which correspond with the "elevator drive means" disclosed in the claims) via a pair of bevel gears 38, 39 are attached to one side of each of the post guides 62, 62, namely, on the side of the posts 16 to which the racks 15 are attached, as shown in FIG. 7 and FIG. 9, and these pinion gears 40 engage with, and travel along the racks 15 on the side of the posts 16, enabling the height adjustable operations platform 8 to move up and down along the posts 16 under its own power.

10 In addition, as shown in FIG. 7 and FIG. 8, guide wheel units 9 are provided at four locations around the outer periphery of the height adjustable operations platform 8. These guide wheel units 9 run along the inner wall surface 1d of the digester 1 when the height adjustable operations platform 8 is raised  
15 or lowered, restricting sideways deviation of the height adjustable operations platform 8 and ensuring stable up and down movement.

In other words, the guide wheel units 9 are constructed by attaching a wheel 10 to the tip of a pivoted arm 11, which  
20 is provided on the height adjustable operations platform 8 and is free to swing in the radial direction of the digester 1, and then using a damper 12 to energize the arm 11 to apply pressure continually in the outward direction. According to such a construction, because the wheels 10 run along the inner wall  
25 surface 1d while being pressed against the inner wall surface with a constant, predetermined pressure, stability during the raising and lowering of the height adjustable operations

platform 8 is ensured at all times, and because the wheels 10 are free to deviate along the radial direction of the digester 1, the wheels 10 are able to accommodate steps (namely, the joint sections between the first through third main body sections 21 to 23 of the main body section 2) in the inner wall surface 1d, and easily ride over such steps, meaning the reliability of the movement of the height adjustable operations platform 8 is ensured.

Because the height adjustable operations platform 8 is carried through the manhole 36 from outside the digester 1, and is then assembled inside the digester, each structural member must be a knockdown structure formed from parts that are of a size capable of passing through the manhole 36, which are then bolted together.

#### 15 C: Cleaning Operation using the Scaffold Apparatus for Operations

As follows is a description of the operating procedure for conducting a CO<sub>2</sub> blast cleaning operation on the inner wall surface 1d of the aforementioned digester 1 using the scaffold apparatus for operations described above.

As described above, in the aforementioned scaffold apparatus for operations that has been assembled inside a digester 1, the aforementioned height adjustable operations platform 8 is freely raised and lowered along the posts 16 between the lower fixed operations floor 6 and the upper fixed operations floor 7, and consequently, as shown in FIG. 1 and FIG. 2, an operator M is placed on the height adjustable

operations platform 8, hoses 24 extending from a CO<sub>2</sub> blast operations unit 20 located outside the digester 1 are passed through the bottom manhole 31 provided in the digester bottom structure 3 of the digester 1 and up onto the top of the height adjustable operations platform 8, the operator M holds a blast nozzle 54 attached to the tip of the hoses 24, and a blast material, namely fine particles of dry ice, projected from the blast nozzle 54 is sprayed onto the inner wall surface 1d, and the impact energy of the blast material removes adherents such as rust from the surface of the inner wall surface 1d, thereby producing a clean surface. By conducting this cleaning operation while the height adjustable operations platform 8 is sequentially raised or lowered by predetermined distance, the cleaning operation is performed in a uniform manner over the entire height of the inner wall surface 1d.

In this case, because the blast material sublimates after projection and becomes CO<sub>2</sub> gas, a post-operation for recovering the blast material, such as that required when steel spheres or the like are used as the blast material, is unnecessary, meaning the operation is very favorable in terms of improving the operating efficiency of the overall cleaning operation, and reducing the operating costs. Furthermore, because of the difference in specific gravity from air, the CO<sub>2</sub> gas accumulates at the bottom of the digester 1, and because a downward ventilation flow exists inside the digester 1, discharge of the gas outside the digester 1 is performed very efficiently, the operating environment inside the digester 1 is maintained at



a good condition, and the gas causes absolutely no harm to the health of the operator M. Coarse particulates generated by the blasting also get carried along the downward flow and are discharged externally from the digester 1, but to avoid  
5 inhalation of these coarse particulates, an air line mask 53 is passed into the digester 1 from the aforementioned manhole 35, as shown in FIG. 1, and the operator M wears this mask.

Focusing on the utility of the height adjustable operations platform 8, because the wheels 10 of each of the guide  
10 wheel units 9 brace the height adjustable operations platform 8 against the inner wall surface 1d, sideways swinging during raising or lowering of the platform is largely inhibited, enabling a more stable, smoother movement, and improving the safety during movement, and furthermore, during a cleaning  
15 operation while the height adjustable operations platform 8 is stopped, even if, for example, the projection of the blast material from the blast nozzle 54 causes a reaction force, the platform is maintained in a stable state with no sideways rolling, enabling a very uniform cleaning operation to be conducted on  
20 the inner wall surface 1d, and ensuring good reliability for the operation.

In addition, because the wheels 10 of the guide wheel units 9 are capable of being displaced freely toward, and away from, the inner wall surface 1d, when the height adjustable operations  
25 platform 8 moves over the joint sections between the first main body section 21 through the third main body section 23 of the main body section 2, even if there are steps formed at these

joint sections, by utilizing the aforementioned displacement function, the wheels 10 easily ride over such steps, and steps in the inner wall surface 1d cause absolutely no impediment to the movement of the height adjustable operations platform 8.

5 As a result, stable vertical movement of the height adjustable operations platform 8 is achieved, meaning the general purpose applicability of the scaffold apparatus for conducting operations on the inner wall surfaces of tower structures of a variety of constructions is improved even further.

10 Furthermore, because the height adjustable operations platform 8 is equipped with the aforementioned motors 30 and is capable of being raised and lowered under its own power, during various operations that use the height adjustable operations platform 8, adjustments to the height of the height  
15 adjustable operations platform 8 is performed easily and quickly, for example in accordance with the requirements of an operator, meaning both the operability and mobility are good. As a result, the operating efficiency of operations that are conducted using the height adjustable operations platform 8 is improved  
20 markedly.

Furthermore on the other hand, focusing on the utility of the entire scaffold apparatus for operations, which incorporates the height adjustable operations platform 8, then in the above embodiment, if the aforementioned posts 16 are put  
25 up inside the digester 1 and the height adjustable operations platform 8 is then attached to the posts 16, then adjustments of the installation height of the height adjustable operations

platform 8 within the digester 1 (that is, the height position at which operations are conducted using the height adjustable operations platform 8) is performed easily and quickly by moving the height adjustable operations platform 8 up or down along the posts 16, and consequently, compared with a conventional case in which, for example, a level adjustment operation such as adding to the scaffold framework is required inside the digester 1 every time the operating height is altered, the operability of inner wall surface operations improves markedly, and because level adjustment operations need not be conducted at great heights, the safety of the operations also improves, meaning both operating cost reductions and improved safety are achieved.

Furthermore, in this embodiment, the aforementioned lower fixed operations floor 6 is attached via the securing pieces 45 provided on the side wall 1c of the digester 1 immediately above the tower bottom structure 3, and the bottom ends of the aforementioned posts 16 are supported by this lower fixed operations floor 6, and consequently the entire weight, including the dead load of the posts 16 and the attached height adjustable operations platform 8, and the weight of the operator M and/or operating materials loaded onto this height adjustable operations platform 8, is supported directly by the side walls 1c at a point immediately above the tower bottom section 3 of the digester 1, via the lower fixed operations floor 6, and the application of load onto the tower bottom section 3 is avoided. As a result, compared with the case in which the entire weight

of the posts 16 and the like are supported by the tower bottom section 3 of the digester 1, that is, the region that is typically constructed from an end plate with a curved surface, the weight of the posts 16 and the like is supported more reliably and in  
5 a more stable manner, and both the reliability of the installation of the posts 16 and the like, and the reliability of the various operations conducted using the posts 16 and the attached height adjustable operations platform 8 are improved. Moreover, because the tower bottom section 3 of the digester  
10 1 has the end plate structure described above, that section is more complex and more expensive to produce than the side wall section 1c, and consequently by not needing to use this tower bottom section 3 as the support site for the posts 16 and the like, damage to the tower bottom section 3 is effectively avoided,  
15 resulting in an improvement of the durability of the digester 1, or a reduction of the production costs.

#### D: Other Factors

In the embodiment described above, the digester 1 was described as one example of the "tower structure" that is the  
20 target of the present invention, but the "tower structure" is not restricted to structures such as the digester 1 with a blast furnace type construction, and for example, also includes comparatively low structures such as oil storage tanks and the like. Furthermore, the aforementioned "tower structure" is not  
25 restricted to pressure vessels such as the aforementioned digester 1, it may be used with comparatively low-pressure structures too.

Furthermore, in the above embodiment, a cleaning operation conducted on the inner wall surface of the digester 1 was described as an example of an operation using the scaffold apparatus for operations, but the scaffold apparatus for operations according to the present invention is not restricted to this operation, and is also ideally applied to a variety of other operations including inspection operations, modification operations, and welding operations. Furthermore, each of these different types of operations is of course conducted individually, or a plurality of operations is conducted conjointly, in parallel.

#### INDUSTRIAL APPLICABILITY

As described above, the present invention comprises either a single post or a plurality of posts put up inside a tower structure from a bottom section thereof toward a top section, and a height adjustable operations platform that is attached in a manner that enables free up or down movement along the posts, and consequently, assembling the posts inside the tower structure and then attaching the height adjustable operations platform means that when any of a variety of operations are conducted on the inner wall surfaces of the tower structure, adjustments of the installation height of the height adjustable operations platform within the tower structure is performed easily and quickly by moving the height adjustable operations platform up or down along the posts, and consequently, a level adjustment operation such as adding to the scaffold

framework is not required inside the tower structure every time the operating height is altered, enabling a marked improvement in the operability of inner wall surface operations, and in addition, because level adjustment operations need not be  
5 conducted at great heights, the safety of the operations improves, meaning the invention is also ideal for achieving both operating cost reductions and improved safety.